Oceanographic Boundary Conditions to Cook Inlet

W. Scott Pegau[1], Edward Cokelet[2], Susan Saupe[3]

1. Kacheamak Bay Research Reserve, 95 Sterling Hwy, Suite 2, Homer Alaska 99603
2. Pacific Marine Environmental Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115
3. Cook Inlet Regional Citizens Advisory Council, 910 Highland Ave, Kenai, AK 99611

Abstract

Measurements of temperature and salinity have been collected during the pass two years at the entrance of Cook Inlet. Surface (3 m) measurements have been collected on the ferry M/V Tustumena between Kodiak and Homer. Profiles have been collected along survey lines through Kennedy and Stevenson Entrances and through Shelikof Strait. This data is used to show the stronger freshwater flows in the summer, differences in water characteristic evolution within Lower Cook Inlet, and the effect of winds on the flow of the ACC in this area. A surprising find is that the densest water is found in Stevenson Entrance rather than the deeper Kennedy Entrance.

Background

The exchange of water in Lower Cook Inlet is affected by the Alaska Coastal Current (ACC), freshwater input into Cook Inlet, shoaling of the bathymetry, strong winds, and vigorous mixing caused by the large tidal range (Figure 1). How these factors mix together is important for understanding the productivity, larval recruitment, and oil spill trajectories. It is expected the freshwater flow and winds that contribute to the coastal flows have strong seasonal cycles. Winter winds tend to be strong and from the northeast. In the summer the winds weaken and have a more westerly component. Snow and ice melt add freshwater in the spring and summer, with increasing freshwater input from rainfall in the late summer and fall.

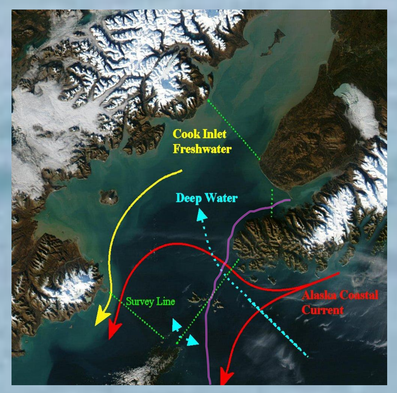

Figure 1. Anticipated water exchange in Lower Cook Inlet. Survey lines are represented by the green dots. The ferry route typically follows along the magenta line.

Methods

Two approaches have been used to measure water properties at the entrance to Cook Inlet for the past two years. The first approach uses instrumentation within the plumbing of the state ferry M/V Tustumena (Figure 2). This is an EVOS funded project, and more details can be found at http://www.pmel.noaa.gov/foci/GEM/alaska_ferry/GEM_ferry.html. Temperature, Salinity, chlorophyll fluorescence, dissolved organic fluorescence, and beam transmission are measured every 30 seconds and nitrate is measured every 10 minutes. The system shuts down when in port. The ferry travels between communities in Southcentral Alaska with monthly trips out the Aleutian Islands. For this poster we are focusing on the data collected between Kodiak and Homer. Several routes are used, but most cross both Stevenson and Kennedy Entrances and pass through the Barren Islands (Figure 1) During most of 2005 the run between these cities occurred twice a week. In the fall the schedule changed so that the route was run nearly daily. The weekly data provides good information on seasonal changes. The daily data is useful in beginning to understand the variability in conditions across Kennedy and Stevenson Entrances.

The second approach used is data collection using a profiling CTD at specific stations along transect lines crossing Kennedy and Stevenson Entrances and Shelikof Strait (Figure 1). A total of 12 cruises occurred during 2004 and 2005. In 2004 the cruises were concentrated in the spring and summer (April, May, June, July, August, September). In 2005 the cruises were spread out to get more winter and fall sampling (January, April, June, July, September, October). At each station a SeaBird 19+ CTD is lowered until the bottom is reached or 180 m of line is paid out (Figure 3). Pressure, temperature, conductivity, chlorophyll fluorescence, beam transmission, and oxygen were typically measured at 4 Hz throughout the cast. We only present data from the down cast.

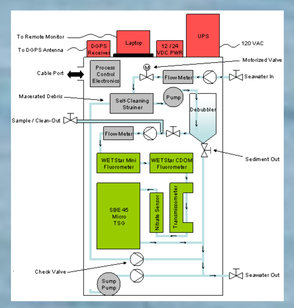

Figure 2. Schematic diagram of the instrumentation in the ferry's shaft alley. Continuous flow through the instrumentation allows us to examine the surface properties along the ferry route.

Figure 3. Deployment of the CTD cage. A lead weight is hung below the cage to make the system hang straighter and to indicate the position of the bottom. Water samples were collected at every fourth station.

Results

The transect data has been divided into three seasons: spring is March through June, during which water temperatures slowly increase; summer is July through October, during which water temperatures are the warmest of the year and freshwater flow increases; winter is November through February when temperatures are cold and salinities are high. Figure 4 shows the seasonally averaged water properties in Kennedy-Stevenson Entrances and Shelikof Strait. Winter data is not presented because only a single cruise occurred during the winter months. In the Kennedy-Stevenson Entrances a salinity gradient exists between the Kenai Peninsula and Shuyak Island with the coldest, most saline waters occurring near Shuyak rather than the deeper Kennedy Entrance. The surface water between the Barren Islands is colder than the adjoining Entrances. High chlorophyll fluorescence was observed in Stevenson Entrance during two of the five spring cruises; however, oxygen concentrations remain low. Water in Shelikof Strait is colder and more saline than the Kennedy-Stevenson Entrances area with the exception of the region near the Alaska Peninsula. Near the Alaska Peninsula a lens of freshwater can be found flowing out of Cook Inlet. This lens of freshwater is also very turbid (as indicated by the low transmissometer voltage).

During the summer the waters warm and increased vertical stratification is found along both transect lines. Salinity in the Alaska Coastal Current flowing into Kennedy Entrance and into Shelikof Strait from Cook Inlet decreases. In Shelikof Strait it also spreads out on the surface, and more saline water fills the deeper portions of the Strait. The freshwater flowing from Cook Inlet is clearer than in the spring. Chlorophyll fluorescence remains high in Shelikof Strait and increases in Kennedy Entrance, while decreasing in Stevenson Entrance.

The temperature and salinity characteristics observed in 2004 are presented in Figure 5. Characteristics in Kachemak Bay (Barabara line) and Cook Inlet (Anchor Point line) increase in temperature in the summer and decrease in surface salinity. The increase in temperature is greater than that observed in Kennedy-Stevenson Entrances or Shelikof Strait. The freshwater flowing down Cook Inlet shifts from being colder than the saltwater in the spring to being warmer in the summer. This evolution is evident in the Cook Inlet and Shelikof Strait data.

The ferry system provides increased temporal resolution of the surface properties. A time sequence of salinity during October 2005 is provided in Figure 6. The predominant winds were from the northwest with occasional shifts to stronger easterlies (Figure 7). The ACC can be seen as lower salinity water entering Kennedy Entrance. Much of the range of conditions can be observed during this week of observations. Most often the core of the ACC is found starting at the 100 m isobath in Kennedy entrance. The ACC is observed on the shelf of Kenai Peninsula typically intruding to somewhere between Point Adams and Point Pogibshi. Most of the time the ACC is a relatively narrow current; however, there are instances, such as on October 13, when the current is much broader (Figures 6 and 8) and appears to enter through both Kennedy and Stevenson Entrances.

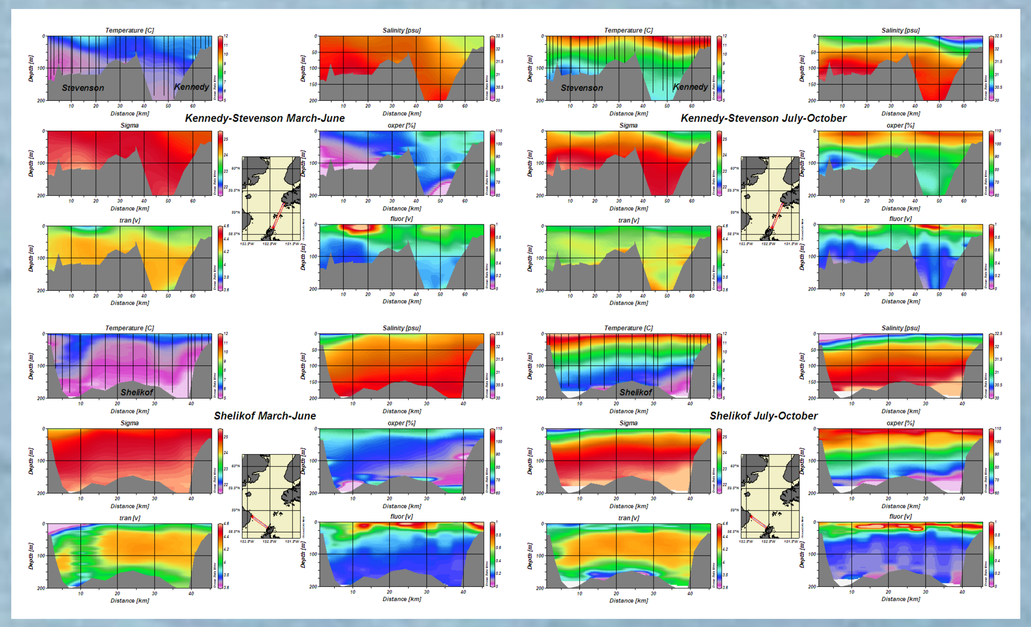

Figure 4. (Above) The seasonally averaged properties along the transect lines in Kennedy-Stevenson Entrances and Shelikof Strait. There were 5 cruises in the March-June period and 6 cruises in the July-October period.

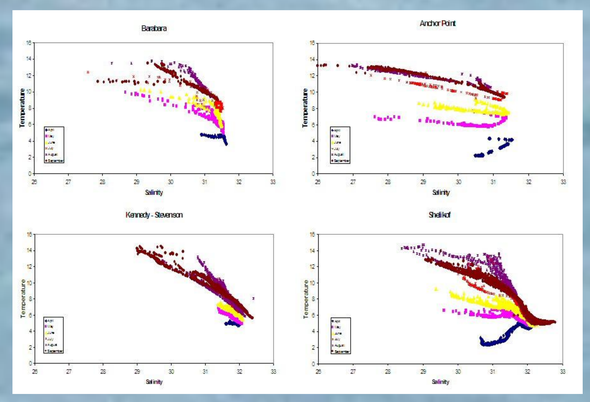

Figure 5. (Right) The temperature salinity characteristics observed along the four transect lines in 2004. Note the influence of freshwater that is present in Cook Inlet and Shelikof Strait throughout the sampling period, but only present in significant amounts during the summer in Kennedy Entrance.

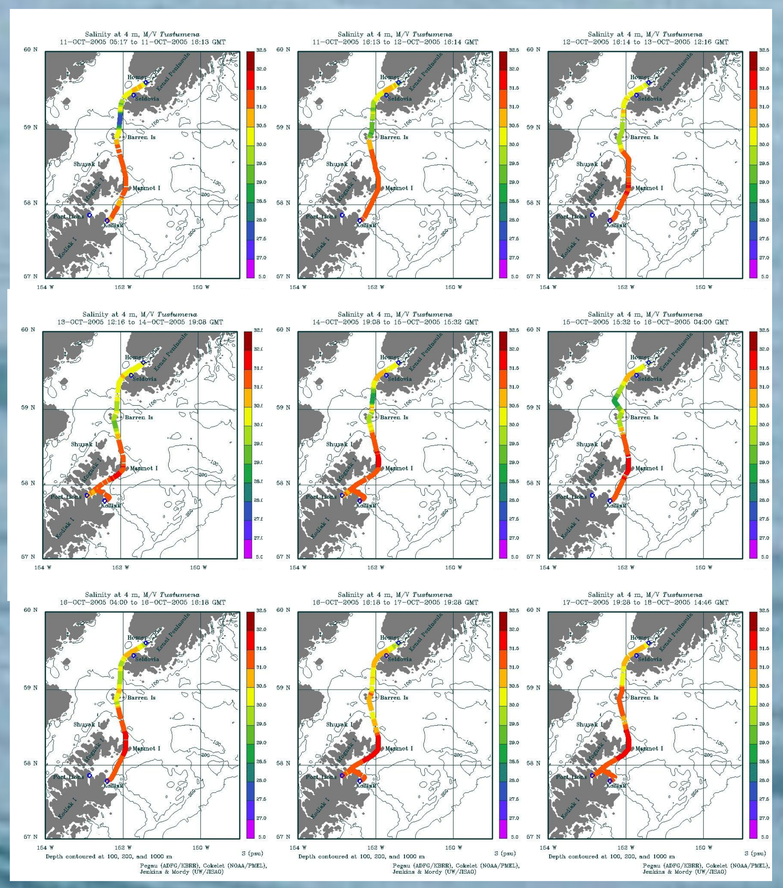

Figure 6. Along-track salinity measured between Homer and Kodiak during nine consecutive crossings in October 2005.

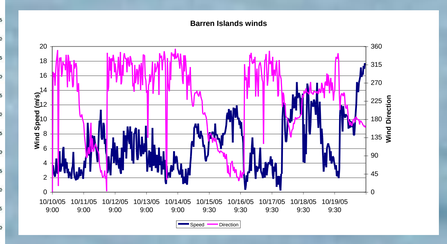

Figure 7. (Below). Wind speed and direction observed at the Barren Island group between Kennedy and Stevenson Entrance. The duration shown covers that provided in Figure 6. Time is in UTC.

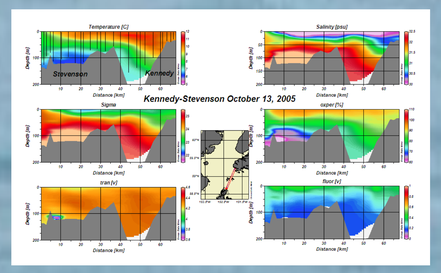

Figure 8. Vertical cross section of oceanographic properties collected during the time shown in Figure 8.

Discussion

Seasonal variability is dominated by solar heating and freshwater input. The Alaska Coastal Current is evident flowing into Kennedy Entrance through the two seasons presented, but is much more prevalent during the summer months. As expected the ACC responds to the winds as well as freshwater input. On those occasions when the wind was from the northwest the ACC was wider and entered through both Kennedy and Stevenson Entrances. When the winds were from the east the ACC was found to be narrower and had lower salinities. The ACC mixes with the large input of freshwater from Cook Inlet before passing down Shelikof Strait.

A close look at the temperature-salinity diagrams for the four transect lines reveals that there is no overlap between the properties observed in Kachemak Bay and Cook Inlet and those found in Kennedy Entrance and Shelikof Strait during the winter and early spring. This suggests that there is little water exchange, and hence larval transport, during those periods. During the summer period there appears to be improved water exchange into Kachemak Bay.

The largest surprise is the presence of cold, high-salinity waters in Stevenson Entrance. These waters are denser than those found in the deeper portions of Kennedy Entrance. During most of the cruises there is little stratification at stations 21 and 22 (in Stevenson Entrance closest to Shuyak Island). The surface salinity found at these stations is similar to that found in Stevenson Entrance at 40 to 80 m depth, suggesting either persistent upwelling or vigorous mixing. A check of the T-S characteristics of the transect stations closest to Shuyak Island along the Kennedy-Stevenson and Shelikof lines shows differences in those characteristics for a majority of the transects completed. This suggests that water exchange between these two areas is intermittent.

Acknowledgments

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